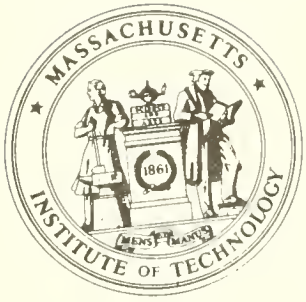

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Roles in Technical Communication Networks

Thomas J. Allen

December 1969 #434-69

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ABSTRACT

The process through which research and development laboratories acquire technical information from outside and disseminate it within their confines is examined. Three very different roles played by organizational members in this process are explored and their incumbents compared on a number of characteristics. This paper was originally presented at the Conference on Communication Among Scientists and Technologists, Johns Hopkins University, October 28-30, 1969.

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The communication behavior of technologists is the focus of concern in the present paper. There are, as I have argued elsewhere (Allen, 1969) many differences between scientists and technologists, and these differences influence greatly their patterns of communication. Perhaps, an interesting exercise for the audience will be to contrast the behavior of technologists, to be described now, with that of scientists as described in subsequent papers.

The Impact of the Organization

Perhaps the most important distinction between scientists and technologists is in their manner of employment. Technologists are, for the most part, employed by bureaucratic, profit-making organizations. This simple fact has an overwhelming influence on their communication behavior. The employing organization cannot afford (or believes it cannot afford) to allow free communication between its members and people outside of the organization. In an attempt to protect its proprietary interests the organization erects barriers to prevent the transmission of its research results to the world at large. This attempt to stem the outward flow of information cannot help but affect inward flow as well. There are, however, even more powerful forces at work to interdict and impede the flow of new technology into the organization.

A very simple examination of possibilities reveals but two direct paths through which technological information from outside can reach members of an organization. Information can be carried in written form through books, journals and documents, or it can be acquired through conversation with outsiders. Unfortunately, recent research reveals severe difficulties in the use of either of these direct approaches to importing technology. First of all, written

material is effective only if it is read. The transfer of paper does not guarantee the transfer of information. Add to this the fact that, as a number of recent studies (Allen, 1966; Auerbach, 1965; North American Aviation, 1967) have sharply pointed out, technologists just do not read very much, and you conclude that the literature is not a very effective vehicle for bringing new information into the organization.

In a slightly different vein, we find that outside personal contact is used very heavily by organizational technologists. In spite of this, personal contact does not appear to be any more effective than the literature for bringing in new information. The reason for this is that the average technologist cannot communicate effectively with outsiders. This is reflected in the results of several research studies which are consistent in their discovery of an inverse relation between outside personal contact and technical performance (Allen, 1964; 1966; Shilling and Bernard, 1964).

How then does information enter the organization? First of all, it is clear that entry does occur, because without it, no R&D organization could long survive. No R&D organization, no matter how large, can be fully self-sustaining. In order for the organization to survive its members must maintain themselves abreast of current developments in those technologies which are central to the organization's mission. It must, in other words, constantly import technical information. Not only were the organizations under study surviving, they were, to all appearances, thriving. They were extremely successful, and highly regarded, technically. They must, therefore, have been successful, somehow, in acquiring information from outside, and disseminating it within their borders. The question remains, how?

The first important clue lies in the observation that, of all possible information sources, only one appears to satisfactorily meet the needs of R&D

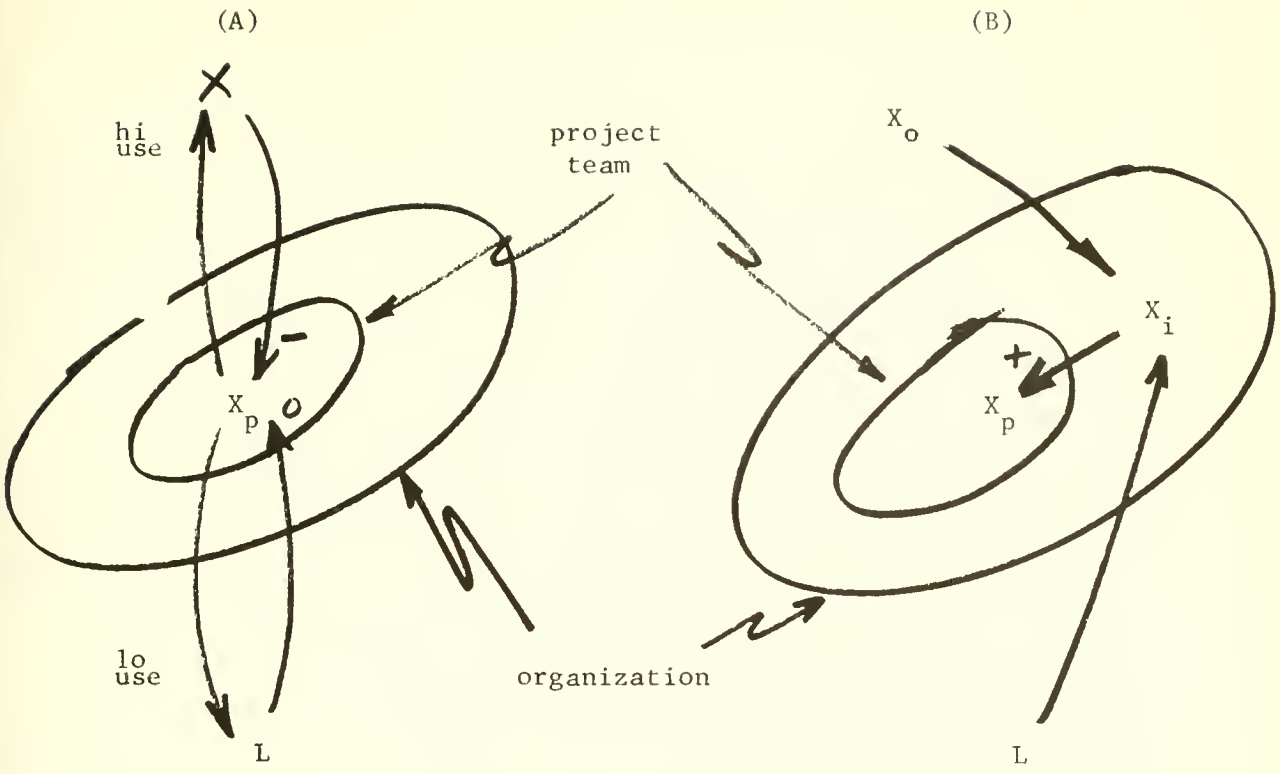
project members. That one source is the organizational colleague. This has been shown in the case of R&D proposal competitions (Allen, 1964) for preliminary design studies (Allen, 1966; Allen, et.al., 1968); for "idea generating groups" (Baker, et.al., 1967); for engineers and scientists in a wide variety of industrial, governmental and university settings (Pelz and Andrews, 1966); and for the members of 64 laboratories in the biological sciences (Shilling and Bernard, 1964).

Following this clue, Allen and Cohen (1969) discovered that the process by which organizations most effectively import information is an indirect one (Figure 1). There existed in the organizations that they studied, a small number of key people upon whom others relied very heavily for information. These key people, or "technological gatekeepers," differ from their colleagues in their orientation toward outside information sources. They read far more, particularly the "harder" literature. Their readership of professional engineering and scientific journals is significantly greater than that of the average technologist (Figure 2). They also maintain broader ranging and longer term relationships with technologists outside of their organizations (Figure 3). The technological gatekeeper mediates between his organizational colleagues and the world outside, and he effectively couples the organization to scientific and technological activity in the world at large.

Characteristics of Gatekeepers

What can be said about the gatekeeper to help in identifying him, and to improve our understanding of the way in which he operates?

The first and most important point that can be made is that in addition to his communication role, the gatekeeper is an important direct contributor



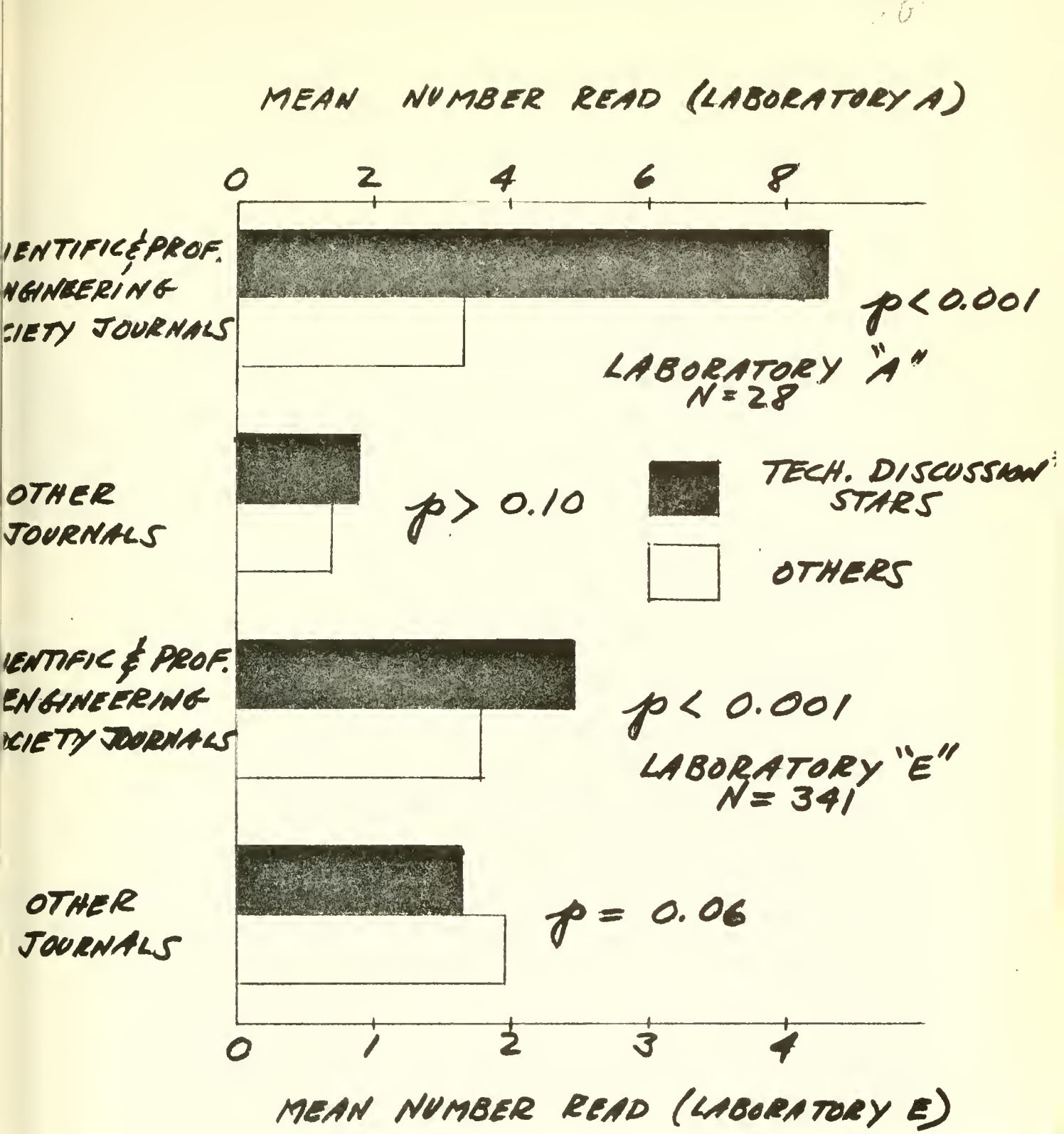
X_p = project team member, in need of information

X_o = person outside of the organization

X_i = organizational colleague

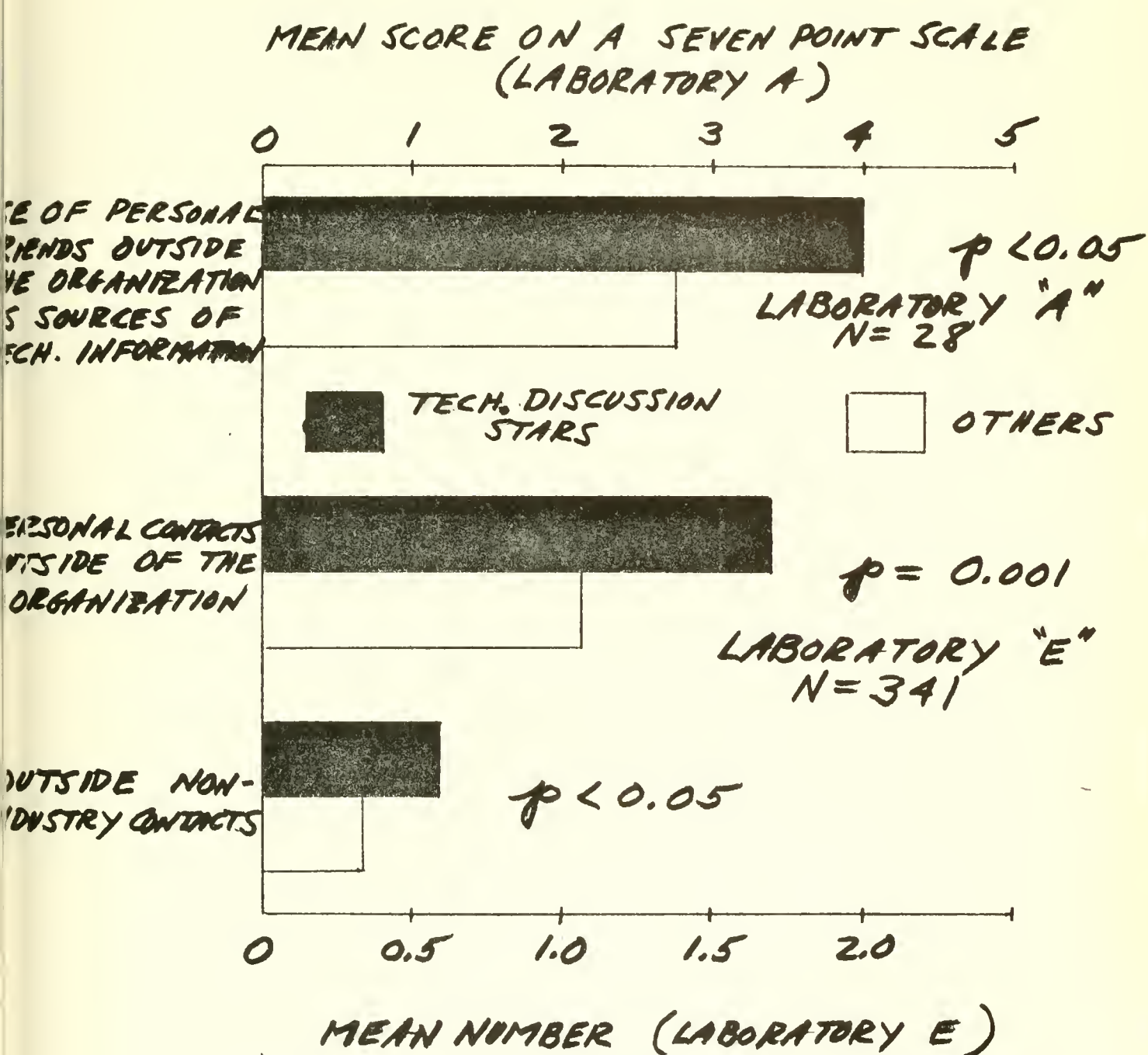
L = literature

Figure 1. The Dilemma of Importing Information Into the Organization. Direct paths do not work (A), because literature is little used by the average technologist and because the direct contact with outside persons is ineffective. An indirect route, through the technological gatekeeper (B) has been shown to be more effective. Symbols next to incoming arrows indicate the polarity of the correlation with performance.



*Persons receiving one standard deviation or more above the mean number of technical discussion choices per person in their laboratory (Laboratory "A") or in their department (Laboratory "E").

Figure 2. Journal Readership by Technical Discussion Stars. Laboratory "A" is the original laboratory reported in Allen and Cohen (1969). Laboratory "E" is the advanced technology component of a large aerospace firm.



*Persons receiving one standard deviation or more above the mean number of technical discussion choices per person in their laboratory (Laboratory "A") or in their department (Laboratory "E")

Figure 3. Personal Contact Outside of the Organization by Technical Discussion Stars. Laboratory "A" is the original laboratory reported in Allen and Cohen (1969). Laboratory "E" is the advanced technology component of a large aerospace firm.

to the organization's technical goals. Gatekeepers[1] in a large (341 engineers and scientists) research and development laboratory were compared on a number of characteristics with their organizational colleagues. Among other things, several attempts were made to measure their performance, and as can be seen in Figure 3, their performance compares quite favorably with that of the average member of their organization. While they hold a slightly larger number of patents than the average for the laboratory, the difference is not statistically significant. They do produce a significantly greater number of papers[2], and are more likely to be among those cited when each chief engineer or chief scientist was asked to name his most important technical contributors, or "key people".

The proportion of gatekeeperswho are first line supervisors is also high (Figure 4). The first line supervisor is perhaps in an ideal position to mediate between his small group (usually six or fewer) and the world outside the organization. Unfortunately, the direction of causality here is not clear. These men might be better able to perform the gatekeeping function because they are first line supervisors, or they might be first line supervisors because the organization has rewarded their performance as gatekeepers. Some support for the latter interpretation is provided by the finding that many

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[1] People who are technical discussion stars and who are either one standard deviation above the mean in readership of scientific or professional engineering journals or above the median in number of outside personal contacts.

[2] They also appear to publish significantly more in scientific and professional engineering journals. Measurement in this case is, however, restricted to those papers produced since joining their current work group and is therefore biased against new members of the group. The measurement of conference papers was not restricted in this way and is therefore a better indicator of career performance.

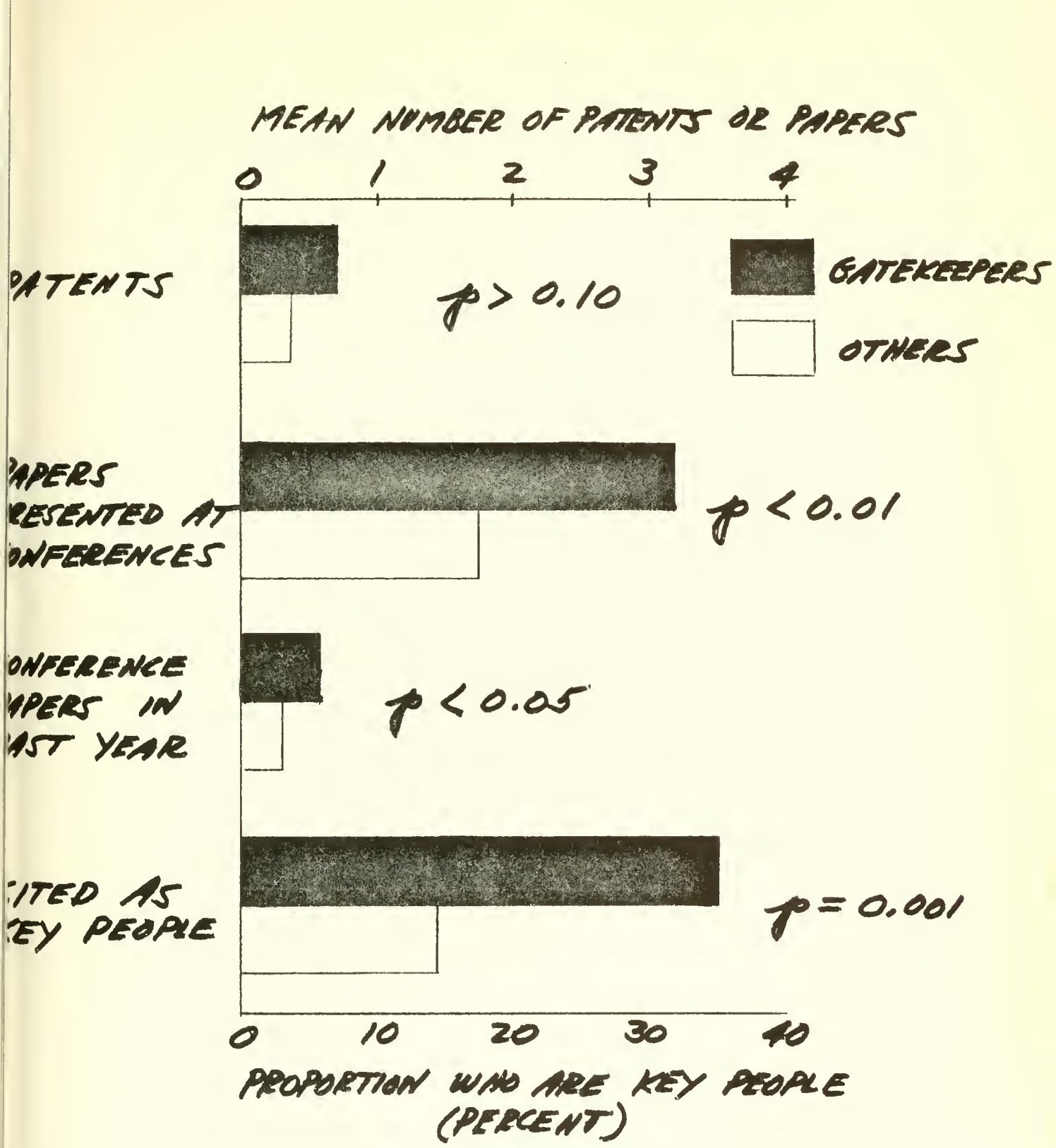

Figure 4. Performance of Technological Gatekeepers

gatekeepers are found among the organization's highest technical performers. They are probably rewarded by promotion for this performance, and for that reason a high proportion of them are first line supervisors. Of course, this must remain but an interesting conjecture until a sample of gatekeepers can be studied longitudinally over time to determine their career paths.

In the meantime it is interesting to see what proportion of gatekeepers hold positions in the organization above that of first line supervisor. At the next level up, the proportion remains relatively high (Figure 4), but beyond that, it diminishes considerably. It is certainly reasonable, that as one ascends the organizational hierarchy the incidence of gatekeepers should diminish. Contact with the rank and file engineer becomes more difficult as the manager ascends the organizational hierarchy. Rank and file contact is, of course, an essential ingredient of the gatekeeping operation. In fact it is surprising to find so high a proportion at the second level of supervision. When this was first observed, it was feared that it might be an artifactof the research method. Second line supervisors might be more highly chosen for technical discussion, as a result of their position in the organization; they might also be better able to communication with people outside of the organization. However, a higher position in the organization usually does not facilitate the reading of scientific and professional engineering journals. In fact it normally militates against it. For this reason, the readership criterion for identification as a gatekeeper was tightened to two standard deviations above the mean to see whether any of the second line supervisors would be eliminated from the sample. Although several people who had been identified as gatekeepers under the one sigma readership criterion were now eliminated, none of these were second line supervisors. The existence

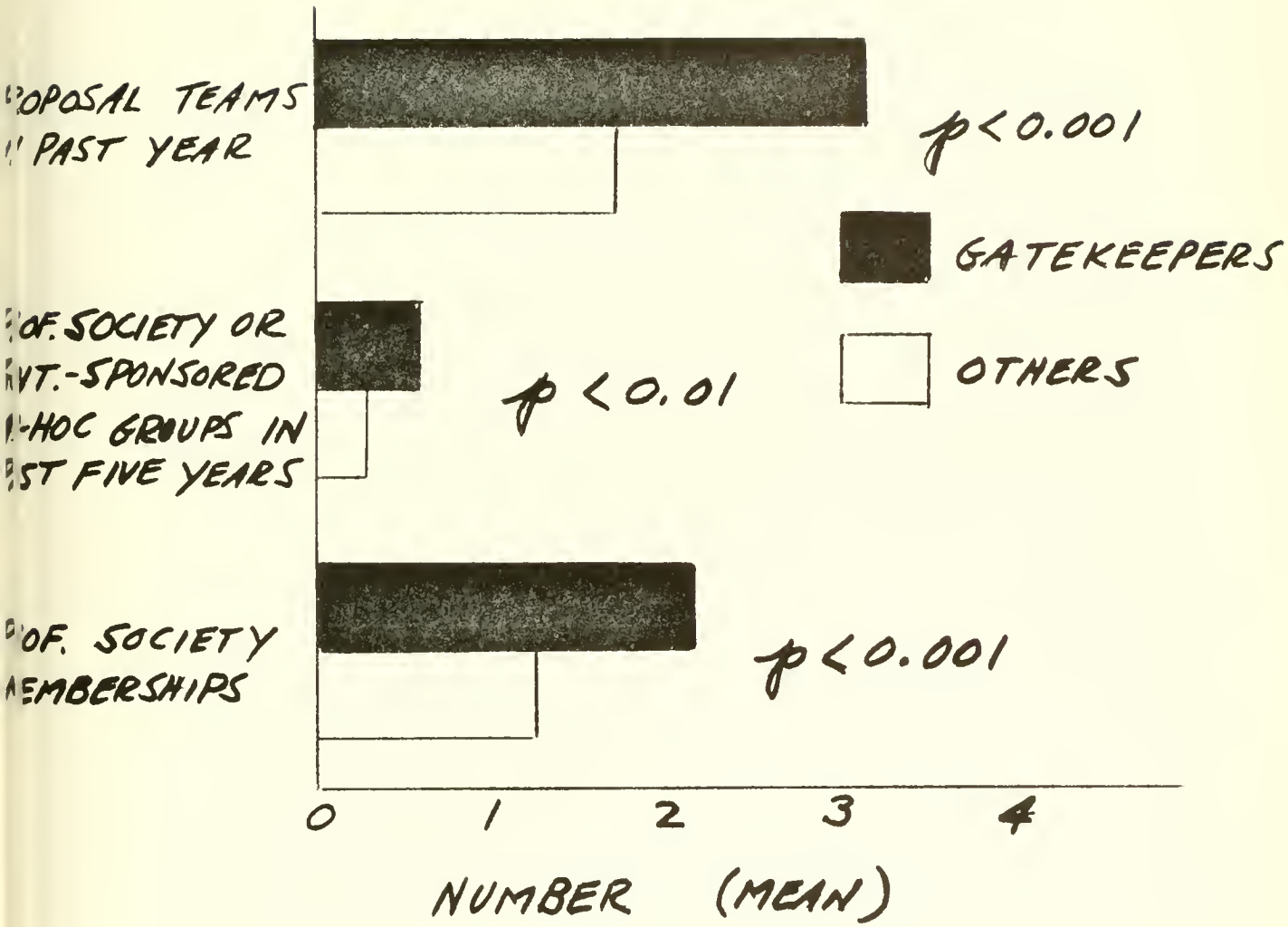

Figure 5 Organizational and Extra-Organizational Activities of Technological Gatekeepers

of second line supervisors among the gatekeepers does not appear to be artifactual at all. Conversation with members of the organization and observation further indicate that these men were functioning quite effectively as gatekeepers, despite their organizational position.

Networks of Gatekeepers

Using the techniques of the earlier (Allen and Cohen, 1969) study, the structure of the communication network in the laboratory was measured. The laboratory was organized on an almost purefuly functional basis around five engineering specialties and three scientific disciplines. There was one interdepartmental project involving fifteen professionals, underway at the time of the study.

The gatekeepers in each specialist department were identified, as well as the structure of the communication network in that department. A communication network involving 400 nodes can be quite complex, unwieldy and difficult to analyze. (See for example Figure 5, which shows the network for a typical department.) For this reason, each of the eight departmental networks were simplified by means of a graph-theoretic reduction.

Any communication network (or any portion of a network) can be characterized according to the degree of interconnectedness that exists among its nodes. Moreover, there are several degrees of interconnectedness or "connectivity" that can existin a network (Flament, 1963). In the present analysis, only that degree of connectivity which Flament labels "strong" will be considered. A strongly connected component, or strong component in a network is one in which all nodes are mutually reachable. In a communication network, a potential exists for the transmission of information between any two members of a strong component (Flament, 1963; Harary et. al., 1965). In other words,

there is at least one path, in each direction, between every pair of members of a strong component. Information held by one member can potentially be transmitted to any other member either directly or through intermediaries.[3] For this reason, the laboratory's communication network was reduced into its strong components and their membership was examined (Figure 6).

When the departmental networks of the organization are reduced in this manner, two things become apparent. First of all, the formation of strong components is not aligned with formal organizational groupings, and second, while there were in each functional department anywhere from one to six non-trivial strong components,[5] nearly all of the gatekeepers are grouped together in the same strong components. (An example is shown in Figure 6.) Although there is a total of 21 non-trivial strong components in the organization, 64 percent of all gatekeepers can be found in eight of these, one for each of the five technological and three scientific specialties. In each technical specialty, there is one strongly connected sub-network containing most of the gatekeepers. The gatekeepers, therefore, maintain close communication among themselves, increasing substantially their effectiveness in coupling the organization to the outside world.

In fact, if one were to sit down and attempt to design an optimal system for bringing in new technical information and disseminating it within the

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[3] The number of intermediaries involved determines the strength of the "cliques" into which any strong component can be further reduced.

[4] The author is deeply indebted to his colleague, Milton L. Lavin, who first suggested this mathematical reduction.

[5] Median for eight departments, of approximately 50 professionals each, is three non-trivial (more than two numbers) strong components.

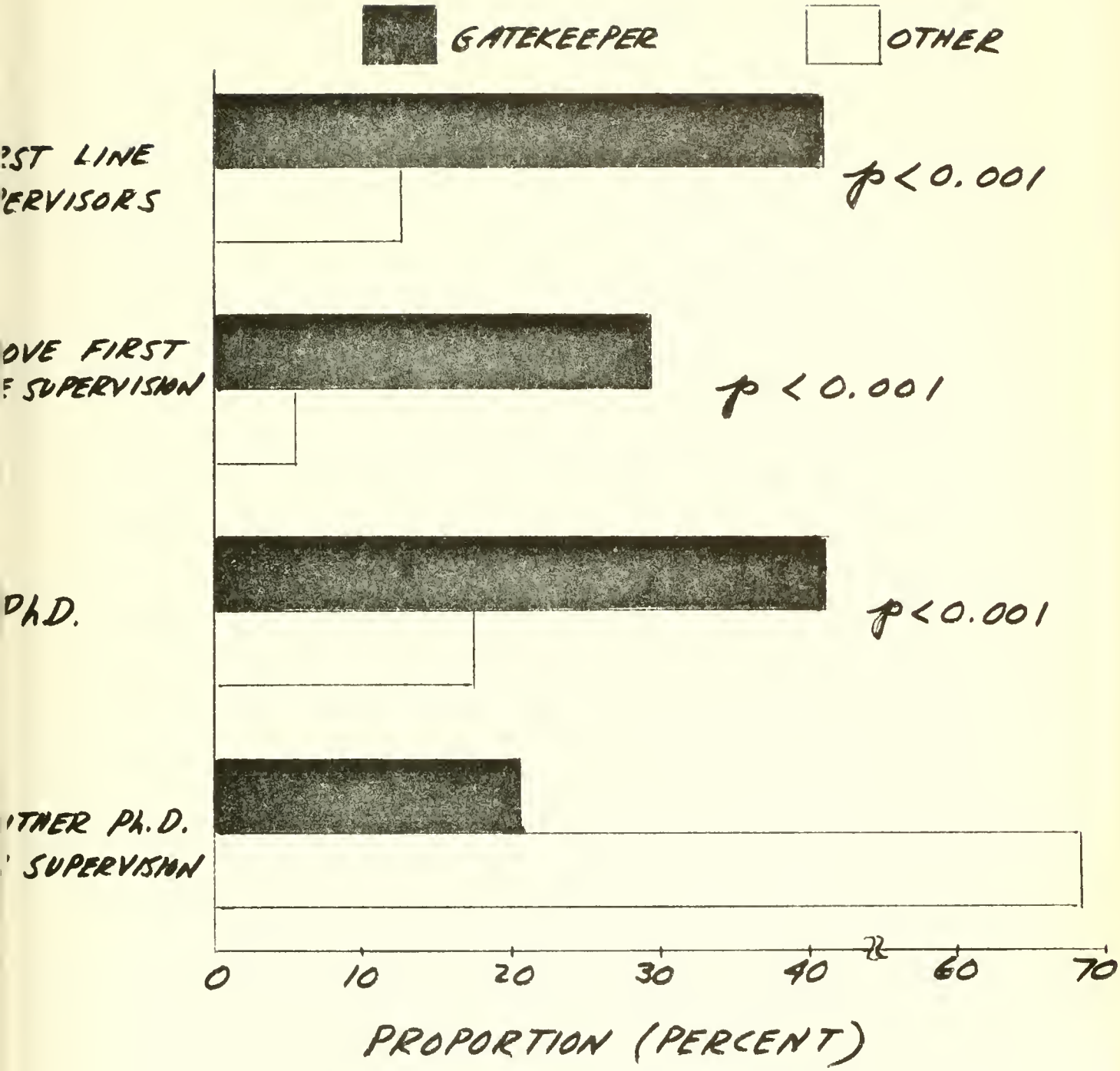

Figure 6. Organizational Position and Educational Status of Technological Gatekeepers

organization, it would be difficult to produce a better one than that which exists. Members of the organization are coupled to the outside world, not through isolated intermediaries, but through a network of intermediaries. The network increases the number of potential paths between any individual and the outside by a factor equal to the number of gatekeepers in the network. This increases considerably the probability that relevant and needed information will not only enter the organization, but eventually reach its user. The process if very simple. New information is first brought into the organization through the gatekeeper. It can then be communicated quite readily to other gatekeepers through the gatekeeper network and disseminated outward from one or more points to other members of the organization (Figure 7). The most intriguing aspect of this process, is the fact that it has developed spontaneously, with no management intervention. There was scarcely a suspicion on the part of management that the network operated in this way.

Liaison Between Departments

The 400 engineers and scientists in the laboratory under investigation were divided about evenly among the eight functional departments. These were highly specialized and it was generally conceded among management, that while a reasonable level of communication existed among them, the situation might still be improved considerably.

It was decided therefore during the course of the investigation to determine the means through which inter-departmental communication was accomplished. It quickly became obvious that a rather small number of individuals were responsible for most inter-departmental communication. Although most of the engineers and scientists reported little contact outside of their immediate

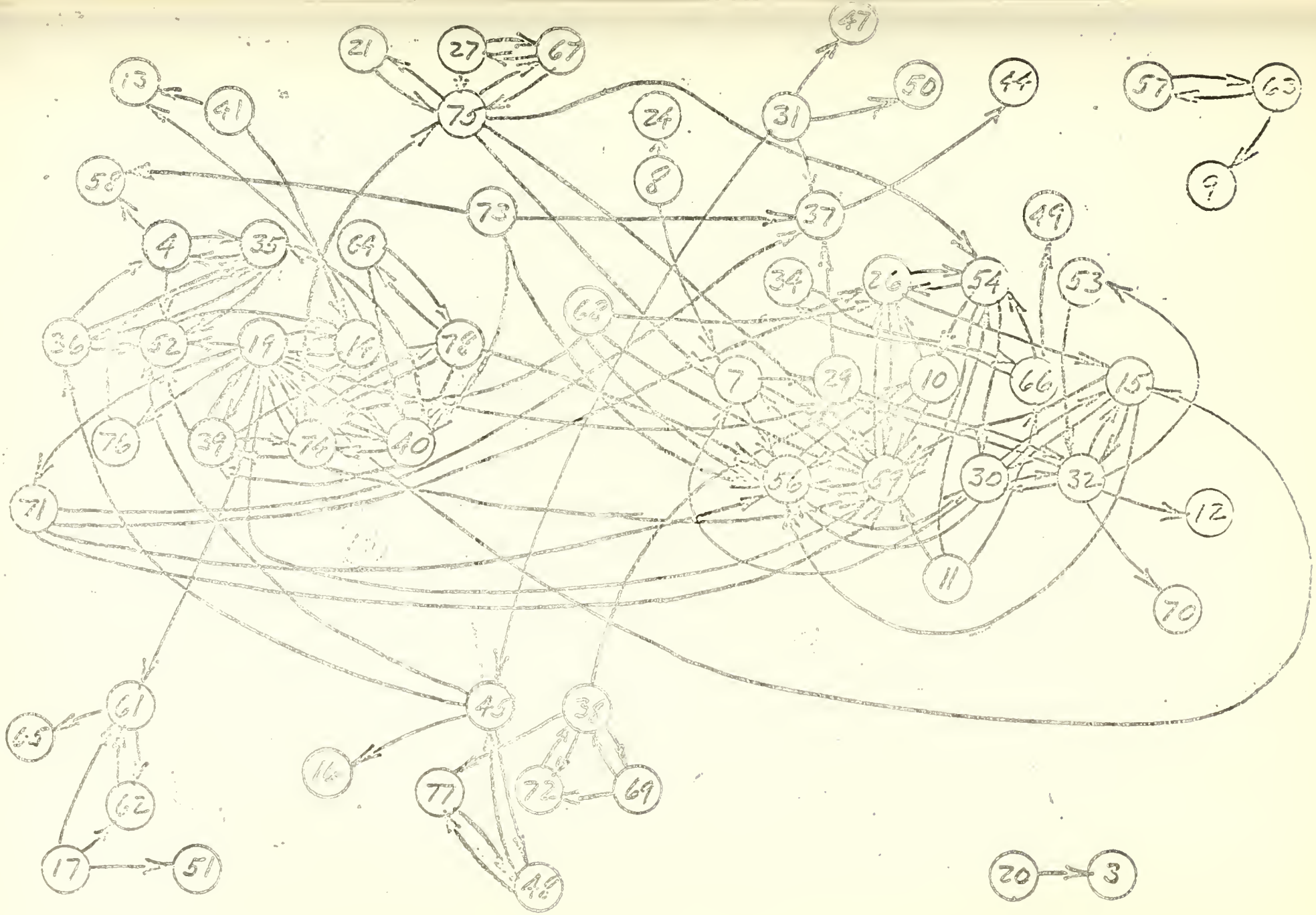

Figure 7. Communication Network of a Typical Functional Department in a Large R&D Laboratory

departments, there existed a small subset who had a very large number of inter-departmental contacts. The two sets of people, those with high inter-departmental contact and those with little or none were compared to determine whether there might be systematic differences in any of their other characteristics.

Before proceeding with the comparison, however, it should be noted that eleven gatekeepers appear among the set of people with high inter-departmental contact. The eleven gatekeepers were named as technical discussion partners by 22 people in other departments. Some of the gatekeepers attract people from outside of their own departments. Moreover, of the 22 outside contacts, only three involved other gatekeepers. The inter-departmental connections provided by gatekeepers, therefore, are not the result of a large interdisciplinary gatekeeper network. The gatekeeper networks appear to be somewhat specialized and confined to single disciplines or technical specialties. The gatekeepers' inter-departmental connections appear to result from their either seeking information from, or providing information to, other disciplines.

For the remainder of the analysis of inter-departmental liaison, the gatekeepers are excluded. Those non-gatekeepers with two or more inter-departmental bonds will be compared with their organizational colleagues in a manner similar to that already performed for the gatekeepers.

The results of this comparison can be summarized quite readily. None of the measured characteristics (age, time with the firm, performance, outside activities, etc.) distinguished the inter-departmental linkers. They were just about average for their organization on every characteristic that was measured. They had been with the organization no longer than the average, their performance, measured in several ways (Figure 8), was just about average,

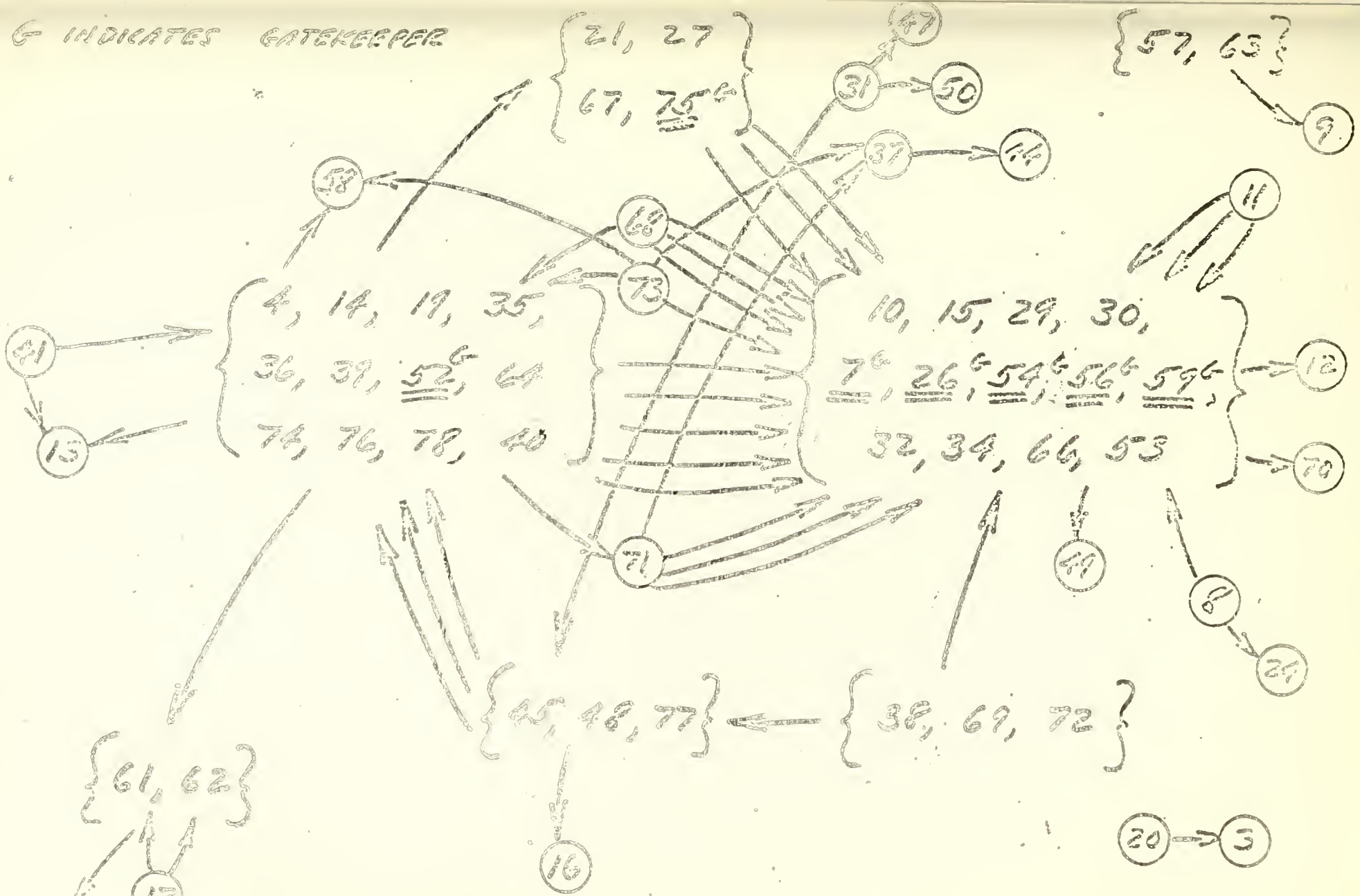

Figure 8. Departmental Communication Network After Reduction into Strong Components (Strong components are shown in brackets, and gatekeepers are shown by underlining with "G" superscript)

and they did not occupy a very high level in the management hierarchy (Figure 9). As a matter of fact, they were very ordinary bench-level engineers. Liaison among the eight departments was accomplished, not at the top of the managerial hierarchy through the chief engineers and chief scientists, as one might expect. It was instead taking place at the bottom of the hierarchy, and it was being accomplished by the working level engineers and scientists.

The fact that inter-departmental liaison was being accomplished by very average members of the organization is particularly interesting when contrasted with the situation for found gatekeepers. Gatekeepers were far from average. They stand out particularly on performance, education and organizational position. The disturbing question remains, however, of just how it is that certain people develop into the liaison role. An important clue lies in the discovery that a very large proportion (36%) of the liaisons were, at the time of the survey, participants in an inter-departmental project an additional four percent were, at the time, on loan from one department to another. The projects and inter-departmental have forced interaction among participants from various departments for at least their duration and possibly for a short period thereafter. This can be interpreted to mean that the liaison role is a transitory one. Following return to his home department a man can provide liaison with the departments he has contacted, buthis effectiveness will decrease with time. The situation is analogous to that found for inter-divisional transfers by Kanno (1968), in which the level of communication between a transferred engineer and his old division decayed exponentially with time.

In another recent study, Lawrence and Lorsch (1967) examined communication among elements of an organization.

They studies the liaison function at a more inclusive level of organization. They were concerned with integrating the three broader functions of

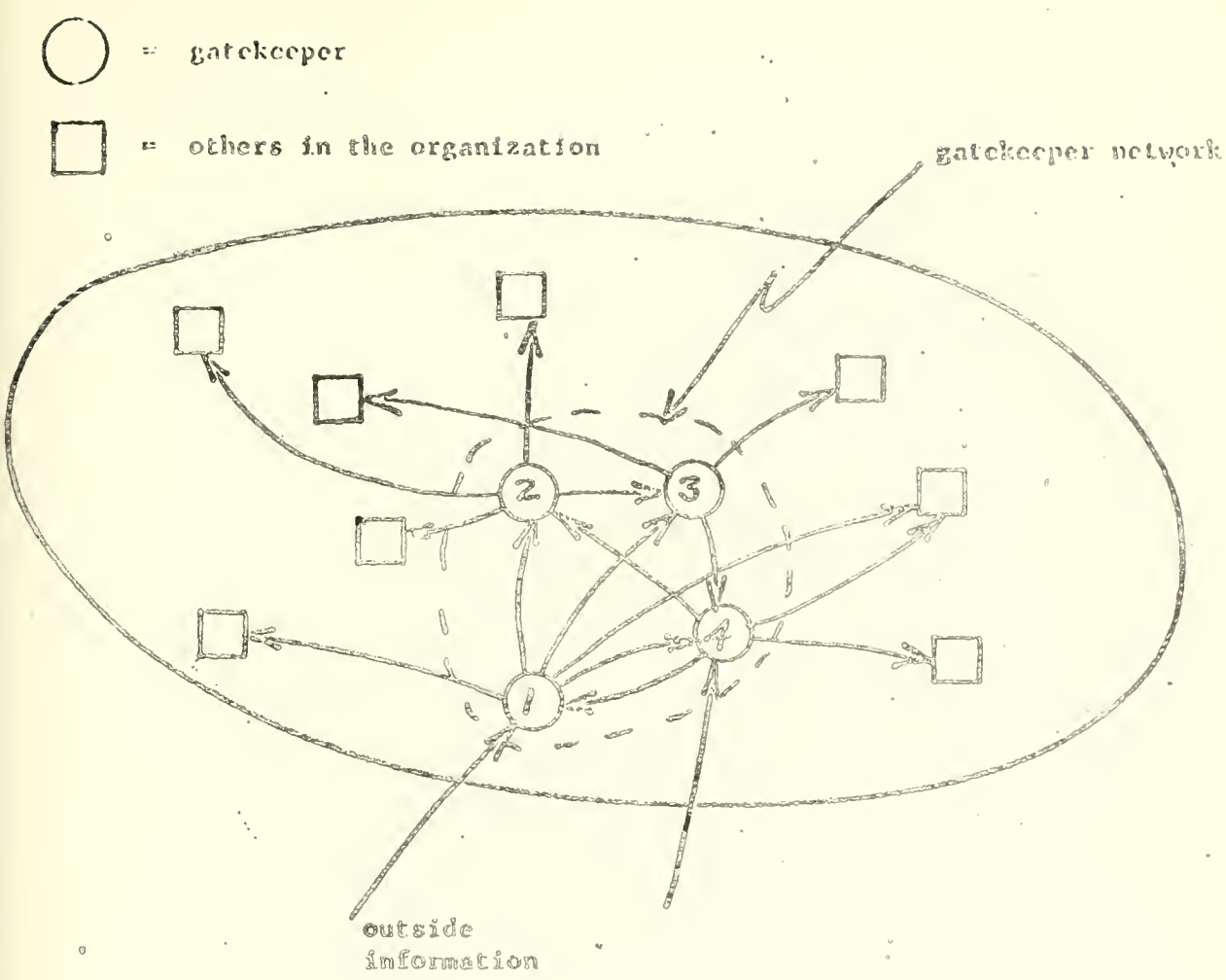

Figure 9. The Functioning of the Gatekeeper Network

New information is brough into the organization by 1. It can be transmitted to 2,3, & 4 via the gatekeeper network. It reaches its eventual users (squares) through their contacts with gatekeepers.

research, marketing and production. Their findings were, therefore, very different. Their "integrators", as they called them, consequently operated at a much higher level in the hierarchy. The inter-departmental liaison function presently under consideration involves departments which are all concerned with research. The nature of the information which is to be communicated is very different. Lawrence and Lorsch were primarily concerned with the communication of information about administrative matters. Those who are higher up in the organization have greater access to this sort of information. In the present case, the information is almost purely technical, consequently just the reverse is true. The further down one is in the hierarchy, the closer he is to this sort of information. Technical information is generated at the working level, and those at the working level have easier access to it. For this reason, liaison among research and development departments is most effectively accomplished at the working level.

The Communication Isolate

A third role which appears upon examination of the communication networks is that of the communication isolate. There were, in the organization, a total of 49 people who were never mentioned by anyone as technical discussion partners. Included among these are six who, in turn (despite the fact that they completed the remainder of the questionnaire in an apparently conscientious manner) did not mention anyone within the organization.[6] Two of the six total isolates are shown in Figure 5 as inverted triangles.

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[6] Three of the six stated explicitly that there was no one within the organization with whom they regularly discussed technical matters. One other named people outside of the organization as technical discussion partners.

The six total isolates do not differ significantly from their organizational colleagues on any of the characteristics that were measured. The only item that approaches statistical significance is the number of years with the company. The total isolates have been with the company an average of 3.7 years. This compares with an average of 5.9 for their colleagues.

Since it is risky to attempt any generalization from a sample of six, it might be more reasonable to examine the more inclusive set of individuals who were never named by anyone as technical discussion partners. This set includes the six total isolates and an additional 43 partial isolates, or people who, although never mentioned by anyone else, did cite others as technical discussion partners.

When these communication isolates are compared with the average member of the organization, in the same way as the gatekeepers and liaisons, some interesting conclusions emerge. First of all, their isolated position stems, at least in part, from the length of time that they have been with the organization. The average isolates had been with the company 4.7 years compared with 5.9 for non-isolates. One would certainly expect new hires to be more likely to be isolated from the communication network, but certainly not for a period of nearly five years. Two years would be a very conservative estimate of the time required to pass out of the "new hire" phase of one's career with an organization. With this assumption, and eliminating those who had been with the company two years or less, we find that the remaining 26 isolates have been with the company significantly longer (7.3 years) than the average. They are not, however, any older than their less isolated colleagues. Despite their longer tenure, they are less active within the organization, having participated in significantly fewer proposal teams. They apparently have never been properly integrated into the organization or its communication network.

Turning back to the full set of 49 isolates, it is apparent that they are generally poor performers (Figure 10). They produce fewer papers, and none of them were among the 57 "key people" nominated by the chief engineers and chief scientists. They are usually at the working level in the organization and there are significantly fewer Ph.D.s among the isolates (Figure 11). The characteristics of the isolate contrast quite sharply with those of the gatekeeper or liaison. The gatekeepers were outstanding performers. The liaisons were average. Now the isolates appear as very poor performers. This is an interesting progression, but it raises once again the difficult question of causality. Are the isolates poor performers because of their isolation, or does poor performance lead to isolation? It is impossible to resolve such a question with a survey of the present sort, conducted at one point in time. A significant clue appears however, when the communication practices of the isolate are examined more generally. Not only is he isolated from the organizational communication network, but he is generally isolated from scientific or technological activity anywhere. The isolates are separated from activities both within their organizations and in the outside community. They report significantly fewer contact with technical personnel outside of their organizations and they read fewer scientific and professional engineering journals (Figure 12). The isolate's isolation is not limited to his immediate organization. He is, for some unknown reason, generally isolated from scientific and technological activity. Whether this is due to poor career choice or some other factor can only be resolved through further research. The fact remains, however, that while poor performance might lead to isolation from organizational colleagues, it is less likely to affect his external relations. Certainly, it shouldn't reduce his reading. One is led to suspect, therefore, that the causal arrow proceeds from communication to

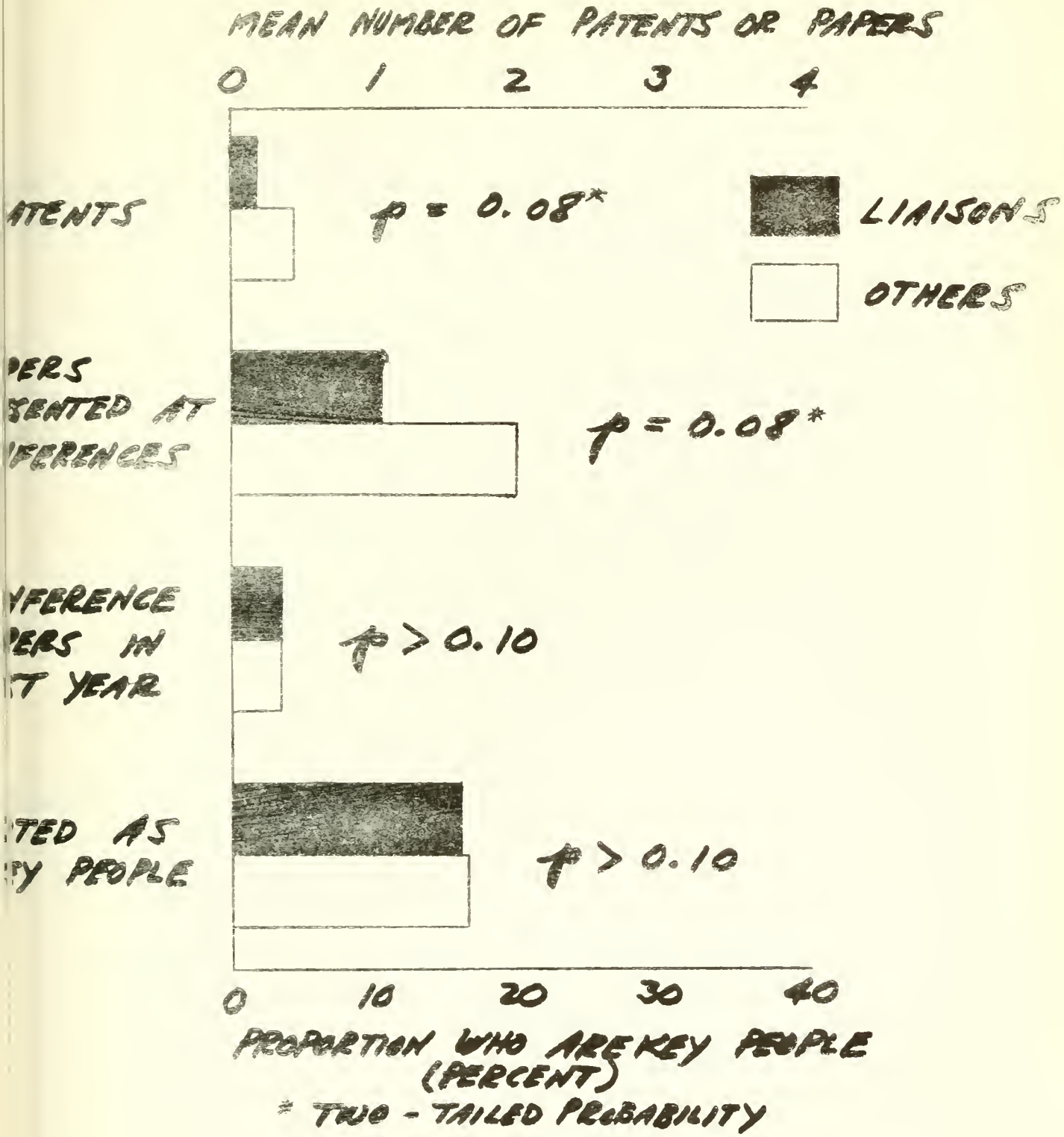

Figure 10. Performance of Inter-Departmental Liaisons

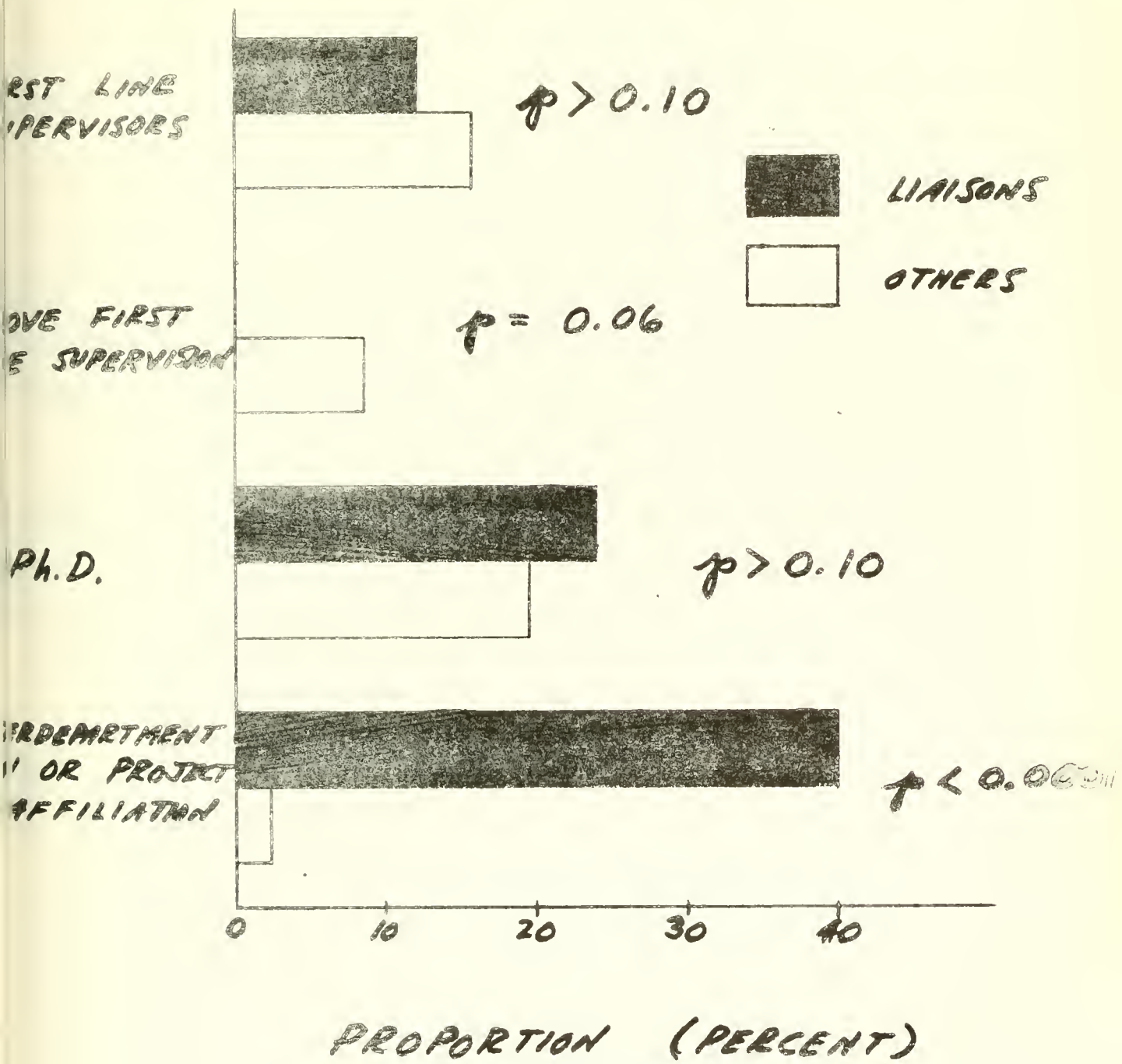

Figure 11. Organizational Position and Educational Status of Inter-Departmental Liaisons

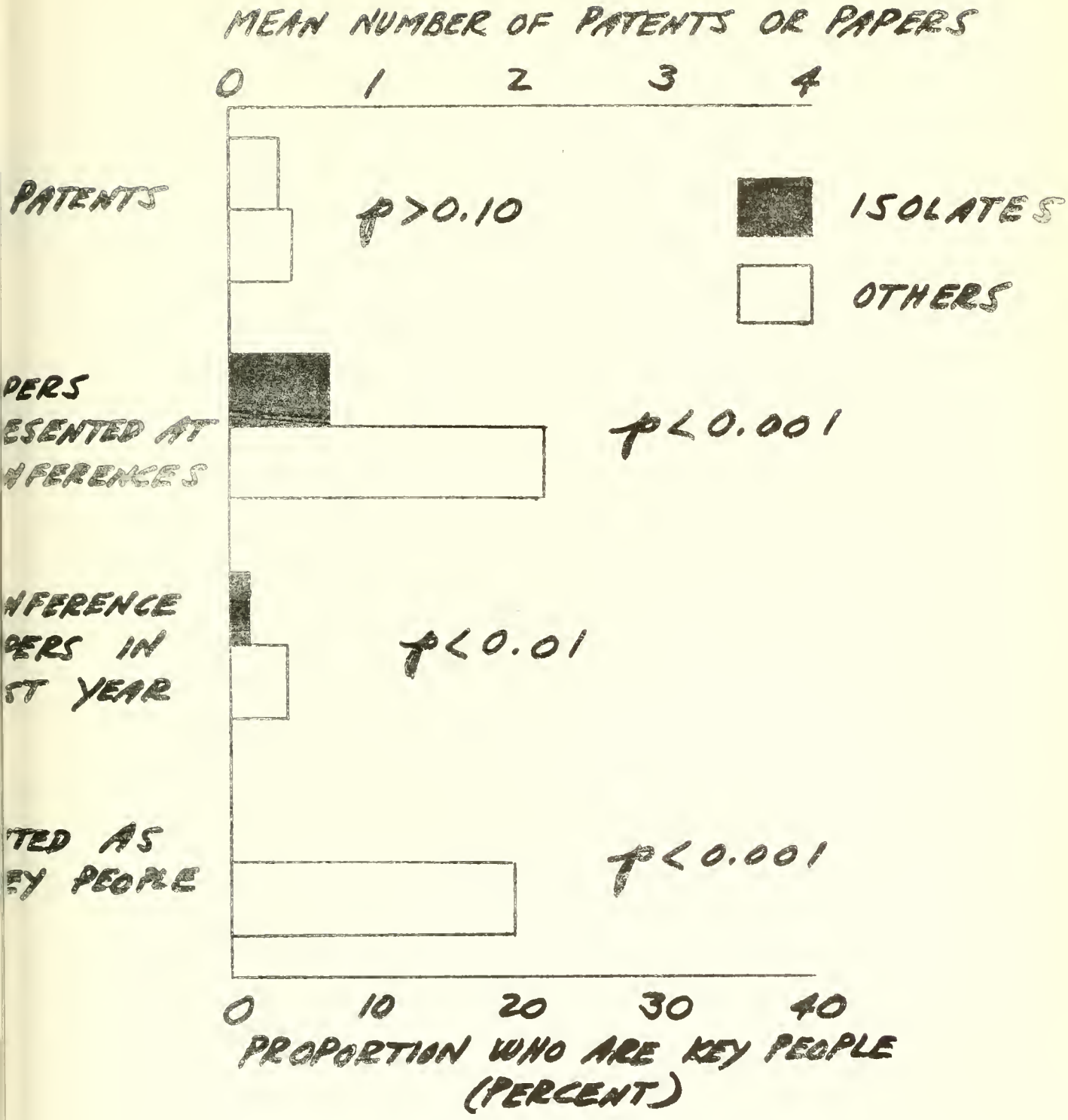

Figure 12. Performance of Communication Isolates

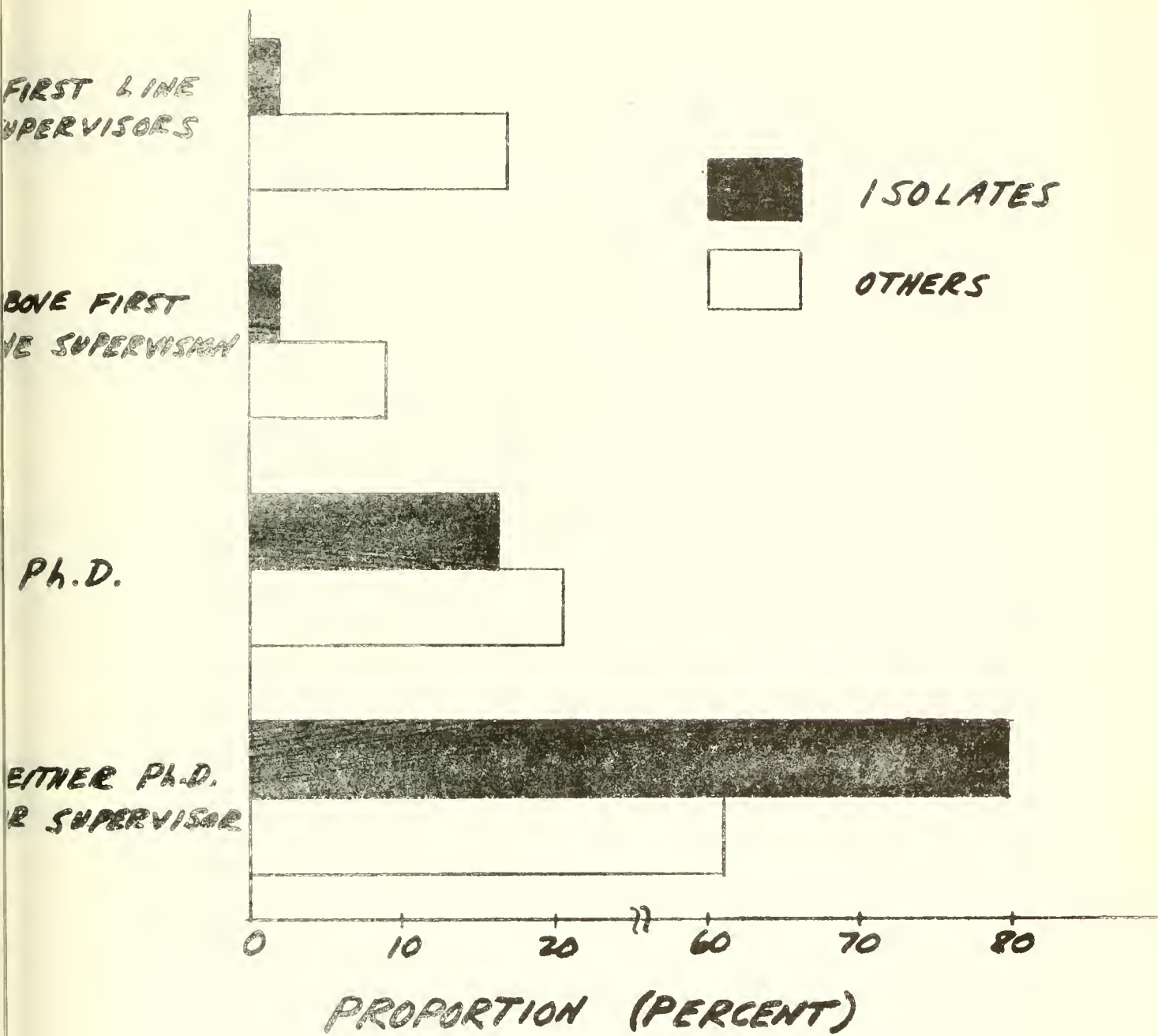

Figure 13. Organizational Position and Educational Status of Communication Isolates

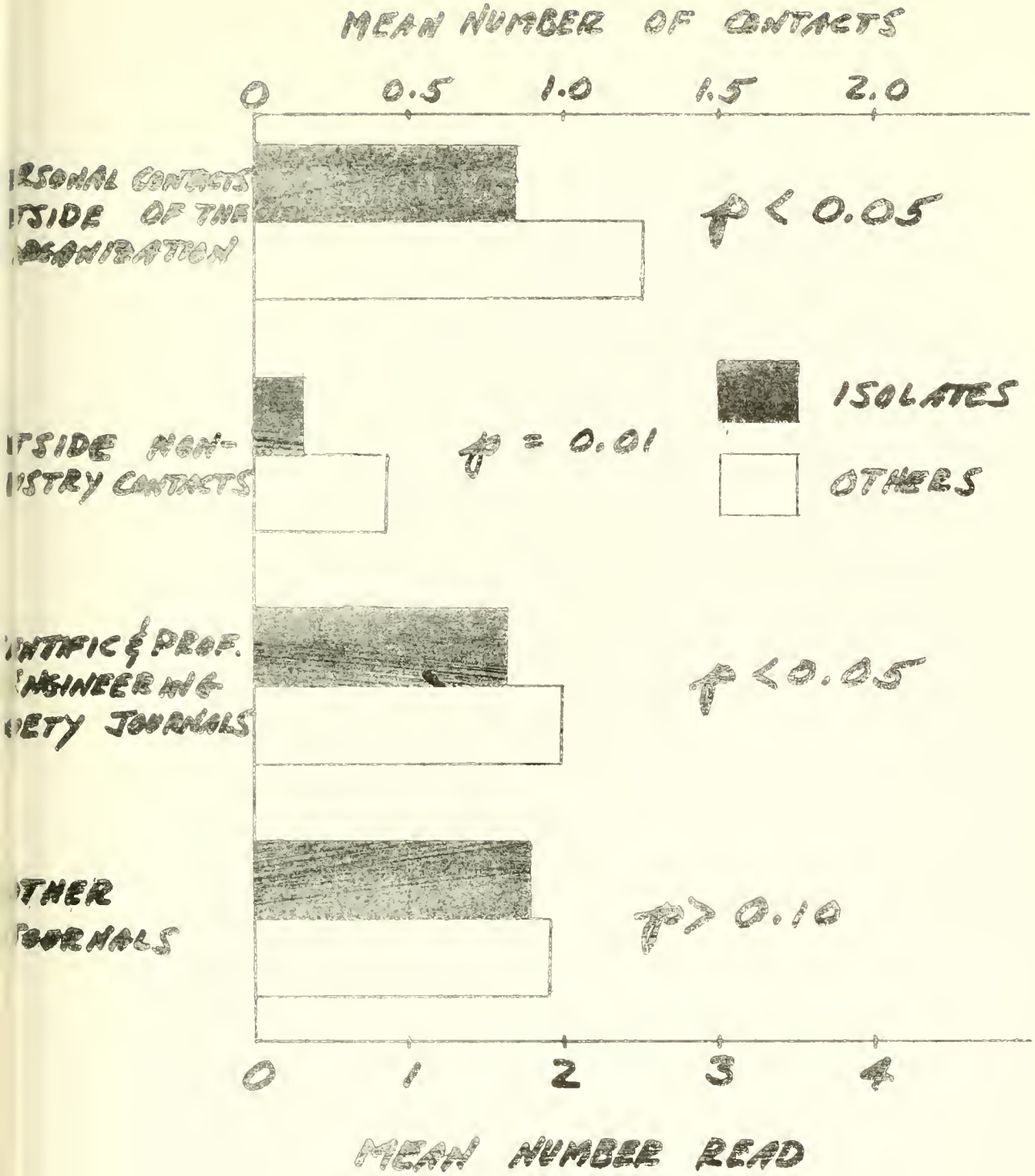

Figure 14. Extra-Organizational Communication Behavior of Organizational Communication Isolates

performance, that being cut off from information on scientific and technological activity, is a major cause of the isolate's poor performance. If this is true, then in at least some cases, action can be taken to prevent organizational isolation from occurring. There are many ways which management can assist the proper integration of personnel into the organizational social system. Integration into the organizational communication network will provide the individual with one means of access to technical information, thereby removing a possible cause of poor performance.

Summary and Conclusions

In order to survive, the technology-based organization must constantly import technical information. Even the very largest firms cannot be self-sufficient. Only a very small fraction of the world's scientific and technological activity will occur within any single organization. To maintain itself abreast of scientific and technological developments, the organization must develop strategies for effective information acquisition and internal dissemination.

Attempts to connect members of the laboratory's technical staff to outside information sources have been ineffective either because of deterrents to use, or difficulty in using specific sources. Research shows that the best path between an outside source and most members of the organization is an indirect one. This indirect path involves the use of technological gatekeepers as intermediaries in the process. The gatekeepers accomplish the important function of coupling the organization to outside activities.

The gatekeeper, in addition to communication role is an outstanding direct contributor to the technical goals of the organization. Furthermore, he

maintains close contact with other gatekeepers through strongly connected subsets within the organization's communication network, and thereby provides multiple potential paths between his "clients" and the world outside.

Besides the gatekeepers, two other roles were found in the laboratory communication network. The inter-departmental liaison is a very average member of the organization. His performance is at an average level, and he appears at about the mean on all other characteristics measured, with but one exception. At some point in his recent experience, he has come into direct contact through work assignment with some department other than the one with which he was affiliated at the time of the study. The effect of this contact persists for a time and provides a channel for communication between departments.

Communication isolates stand out as low performers. The fact that their isolation is more general than mere organizational isolation, leads one to suspect that it is the cause rather than an effect of poor performance. Final resolution of this question must, however, await the conclusion of longitudinal studies which are currently underway.

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